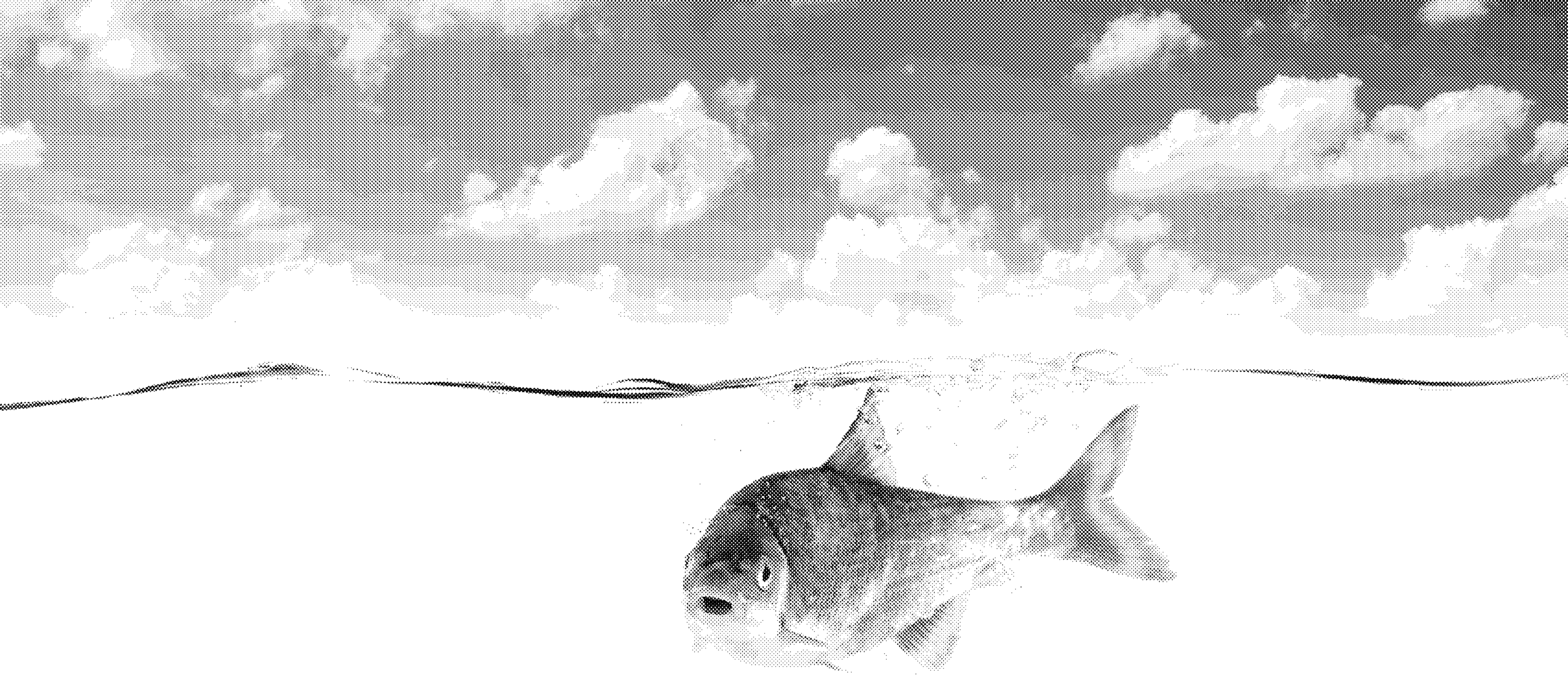

Standard Operating Procedure

In Situ Water Quality

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1 INTRODUCTION

1.1 Background

In situ water quality assessment includes measurement of pH, conductivity, dissolved oxygen, and temperature[1]. These variables are measured in the field using appropriate meters. The detailed standard operating procedures for each field measurement are provided in the sections that follow. Given the wide variety of meters currently available (including single and multi-purpose meters), follow manufacturer's instructions for specifics on proper calibration, use, storage, and maintenance. Meter failure can occur in the field, so it is good practice to have a back-up meter, if feasible. If a working meter is not available, water samples can be collected and submitted to an analytical laboratory for analysis of pH and conductivity.

Some analytes which are analyzed in the laboratory require associated field measurements in order to allow evaluation against guidelines for the protection of aquatic life. For example, the toxicity of ammonia to freshwater life is relative to both the pH and the temperature of the water, so these analytes must be measured in the field in conjunction with sampling.

[1] Depending on the instrument and probes installed, a number of other measures may be possible (e.g., total dissolved solids, salinity, turbidity). Do not record these if the probe has not been properly calibrated or maintained.

2 pH MEASUREMENT

2.1 General Information

pH is the logarithm of the reciprocal of the hydrogen ion concentration. Most surface waters have pH values from 6 to 9. pH is considered to be a key variable controlling the chemical form (speciation) of metals and nutrients in aquatic systems. Low pH will generally result in metals being present in their ionic form, which can be more readily available to aquatic organisms than other forms. The combination of the direct effects of high hydrogen ion concentrations and the indirect effects of increased ionic metals can result in reduced biodiversity below a pH of approximately 5. The instrument (meter) method of measuring pH is most appropriate for the majority of monitoring programs.

2.2 Calibration, Measurement, and Data Recording Procedure

A wide variety of pH meters and multi-parameter meters with pH probes are currently in use and allow for direct measurements in the field. Follow manufacturer's instructions for specifics on proper calibration, use, storage, and maintenance.

Generally, calibration, pH measurement, and data recording are as follows:

a. Verify the calibration of the pH meter each day prior to use by measuring the pH of standardized buffer solutions. The meter must be re-calibrated if the meter readings do not meet precision and accuracy objectives.

b. For accurate results, use a minimum of two pH calibration standards that bracket the pH of the waterbody being monitored. Use pH standards 7 and 4 if measuring more acidic waters, and 7 and 10 if measuring more basic waters. To maintain the highest accuracy of the instrument, the temperature of the standard buffer solutions should equal the temperature of the waterbody being monitored, and solutions should not be expired or contaminated.

c. Turn on the meter and set it to measure the first calibration standard. It is important to always start with the neutral pH 7 buffer. Since pH solutions are temperature dependent, the buffer value may need to be adjusted slightly. The calibration solution container should have a list of pH values at different temperatures.

d. Immerse the pH electrode into the pH 7 buffer solution, the instrument should recognize the buffer value (if not, enter in the pH value). Once temperature and pH have stabilized (this may take a few minutes), follow instructions in the operation manual to accept the calibration and continue to the next step.

e. Rinse the probe with clean water (tap water or ambient water are acceptable).

f. Immerse the probe in the second buffer solution and follow instructions in the operation manual.

g. Once calibration using both buffers is complete, rinse the electrode again before storing or immersing the electrode in the ambient water to be measured.

h. Record the calibration in the probe logbook.

i. To start measuring, immerse the pH probe in the ambient water and follow instructions in the operation manual to obtain a measurement. The probe may need to be gently moved through the water for the reading to reach equilibrium.

j. Once the reading reaches equilibrium (this may take a few minutes), record the pH on the appropriate data sheet.

k. Record additional pertinent information in field notes. Accurate field notes must be kept throughout the field program, including the rationale for any decisions pertaining to the use of the pH meter.

l. Whenever the pH meter is not in use, immediately store it according to instructions in the operation manual. Typically, probes are stored in a plastic cover with a small amount of water. If long term storage is required (i.e., >30 days), refer to the operation manual regarding specific procedures.

2.3 Maintenance

The probe's glass membrane is very fragile and needs to be handled with care. In general, the only maintenance required for the pH meter is battery replacement and probe cleaning. pH calibration solutions expire in 6 months (opened) or 2 years (unopened). Replace the solutions when they are expired, when obviously contaminated (visible bits of foreign matter in the bottle), or clearly inaccurate. Conduct all maintenance in accordance with manufacturer's instructions.

3 CONDUCTIVITY MEASUREMENT

3.1 General Information

Conductivity is a measure of the ability of an aqueous solution to carry an electric current. This ability will depend on the type and concentration of ions present in the water being measured, as well as temperature. Conductivity provides insight into the total concentration of ions (e.g., high metal concentrations) and also into the chemical behaviour of metal ions in solution. It also provides insight into the biological uptake of metals ions (i.e., ion balance issues can become challenging at high ionic strength). Since the conductivity of solutions changes with temperature, measurements made by some instruments include a correction to estimate conductivity at 25°C which is called the specific conductivity (or specific conductance).

Specific conductivity can be calculated using conductivity and temperature, as follows:

specific conductance = conductivity/[1+0.0191 x (temperature – 25)]

The information provided below applies to measurements of both conductivity and specific conductivity.

3.2 Calibration, Measurement, Data Recording Procedure

A variety of conductivity meters and multi-parameter meters with conductivity probes are currently in use which allow for direct measurements in the field. Generally, conductivity measurements are based on an electric current moving between two electrodes situated in the two holes at the end of the probe. The units in which conductivity is expressed may vary among meters and may be expressed as µS/cm, mS/cm, µmhos/cm, or simply as cm^{-1}. Refer to the operation manual of your meter for information on units as well as specifics on proper calibration, use, storage, and maintenance.

Generally, calibration, measurement, and data recording are as follows:

a. Verify the calibration of the conductivity meter each day prior to use. Recalibrate the meter if the readings do not meet precision and accuracy objectives.

b. To maintain the highest accuracy of the instrument, the temperature of the standard buffer solution used for calibration should equal the temperature of the waterbody being monitored.

c. Turn on the meter and set it to measure the calibration standard.

d. Immerse the entire conductivity probe up to, and including, the hole near the top of the probe, into the solution. Gently move the probe up and down to remove any air bubbles from the conductivity sensor and follow instructions in the operation manual.

e. If calibrating conductivity, it is necessary to look up the value of the solution at the current temperature and enter that value. Most conductivity solutions are labelled with a value at 25°C. If calibrating specific conductance, enter the value listed for 25°C.

f. Allow the meter to stabilize, then accept calibration.

g. Once calibration is complete, rinse the probe with clean water (tap water or ambient water are acceptable) before storing or immersion into the ambient water to be measured.

h. Record the calibration in the probe logbook.

i. To start measuring, completely immerse the conductivity probe in the ambient water and follow instructions in the operation manual to obtain a measurement. The probe may need to be gently moved through the water for the reading to reach equilibrium.

j. Once the reading reaches equilibrium (this may take a few minutes), record the conductivity on the appropriate field sheet. Pay careful attention to whether the meter is measuring conductivity or specific conductance and ensure that the field notes reflect this.

k. Record additional pertinent information in field notes. Accurate field notes must be kept throughout the field program, including the rationale for any decisions pertaining to the use of the conductivity meter.

l. Whenever the conductivity meter is not in use, immediately store it according to instructions in the operation manual. Typically, probes are stored in a plastic cover with a small amount of water. If long term storage is required (i.e., >30 days), refer to the operation manual regarding specific procedures.

3.3 Maintenance

The only maintenance required for the conductivity meter is battery replacement and using a small brush to clean out the probe cavities on occasion. Conductivity calibration solution expires in 1 month (opened) or 12 or 18 months (unopened, glass versus plastic respectively). Replace the solution when obviously contaminated (visible bits of foreign matter in the bottle), or clearly inaccurate. Conduct all maintenance in accordance with the operation manual.

4 DISSOLVED OXYGEN MEASUREMENT

4.1 General Information

Measurement of the oxygen dissolved in water provides information on the chemical and biological status of a waterbody. Oxygen is a requirement of aerobic life and low levels of dissolved oxygen (DO) can indicate low biodiversity. In addition, oxygen is the ultimate electron donor; therefore its presence indicates an oxidizing environment. Thus, most metals and nutrients will be present in their most oxidized state in water with high levels of DO.

Most DO meters automatically measure and compensate for temperature and can be adjusted for salinity. Probes are typically composed of two electrodes (a gold cathode and a lead anode) in an electrolyte solution behind a Clark-type membrane. Probes are usually equipped with a thermistor. This method is applicable to surface waters and waste waters with DO concentrations greater than 0.1 mg/L.

4.2 Calibration, Measurement, Data Recording Procedure

A variety of DO meters and multi-parameter meters with DO probes are currently in use which allow for direct measurements in the field. DO is typically expressed in units of percent saturation and milligrams per litre (concentration). Refer to the operation manual of your meter for information on units as well as specifics on proper calibration, use, storage, and maintenance.

Generally, calibration, measurement, and recording data are as follows:

a. Calibrate the DO meter each day prior to use, and potentially multiple times per day if moving among areas of high and low elevation. Re-calibrate the meter if the readings do not meet precision and accuracy objectives.

b. To start the calibration procedure, turn the meter on and set it to calibration mode. Calibrating DO as percent saturation will automatically calibrate DO in mg/L.

c. Insert the probe into a plastic bottle containing either a small amount of air-saturated water or an appropriate amount of standard. Ensure that the DO sensor is NOT immersed in water. Depending on the meter, the atmospheric pressure may need to be known and keyed into the meter, or the meter may automatically measure atmospheric pressure.

d. Allow approximately 10 minutes for the air in the cup to become water saturated and for the temperature to equilibrate.

e. Once the percent saturation reading stabilizes (this may take a few minutes), follow instructions in the operation manual to complete the calibration.

f. Record the calibration in the probe logbook.

g. When calibration is complete and if a standard was used, rinse the probe (tap water or ambient water are acceptable) before storing or immersion into the ambient water to be measured.

h. To start measuring, immerse the DO probe in the ambient water and follow the operation manual. The DO probe requires constant stirring and/or water movement when taking measurements. If in still or slow water, move the probe around slowly until the reading stabilizes (this may take a while), if measurements are being taken in a fast flowing stream, the probe can be held in place or rested on the cobble/gravel bottom.

i. With experience, you should be able to tell if a reading seems correct. Flowing water is generally well-oxygenated. Macrophytes and algae can affect DO (photosynthesis = high DO, decomposition = low DO) and stagnant, still water can have much lower DO. Super-saturation can occur under certain conditions (i.e., readings over 100%), but very high values are generally suspect (e.g., 120%).

j. Once the reading reaches equilibrium (this may take a few minutes), record the DO on the appropriate field sheet.

k. Record additional pertinent information in field notes. For example, note any odd measurements (e.g., very low (<40%) or very high (>110%) DO) and verify the reading using an alternate device, if available (e.g., DO Hach kit). Also, note conditions that could interfere with readings (e.g., high suspended solids). Accurate field notes must be kept throughout the field program, including the rationale for any decisions pertaining to the use of the DO meter.

l. Whenever the DO meter is not in use, immediately store it according to instructions in the operation manual. Typically, probes are stored in a plastic cover with a small amount of water. If long term storage is required (i.e., >30 days), refer to the operation manual regarding specific procedures.

4.3 Maintenance

If the DO probe has been stored for an extended period, the probe appearance is abnormal (e.g., large bubble(s) inside of membrane), the o-ring is tearing, the membrane has not been changed for two or more weeks (depending on frequency of use), significant deposits of dried electrolyte are visible on the membrane, the sensor shows unstable readings or takes a long time to stabilize, readings appear to be incorrect (repeatedly) and/or the meter detects a poor probe condition, then the probe may require maintenance such as replacing the o-ring, electrolyte solution, or membrane.

Generally, replacing the electrolyte solution and membrane involves the following steps (refer to operation manual for specific instructions):

a. Prepare oxygen probe electrolyte solution.

b. Remove old membrane and thoroughly rinse sensor tip with de-ionized water.

c. Add a few drops of solution on to the top of the probe, allowing a meniscus to form. Carefully place the new membrane onto the sensor ensuring that there are no air bubbles trapped under the membrane.

d. Allow the probe to stabilize (by storing it in the plastic cover with a small amount of water) at least 3 hours (preferably overnight) before calibrating and taking measurements.

e. If, following calibration, measurements still appear off or stabilizing takes a very long time, the electrode may need cleaning. Remove the membrane and use the sanding disk to lightly sand the electrode using one continuous motion across the surface (similar to slowly striking a match). Only a few passes are required. Rinse the membrane well with de-ionized water after sanding. Continue with membrane installation.

Keeping the membrane clean and moist extends its life; however, refer to the operation manual for specific instructions on probe maintenance.

5 TEMPERATURE MEASUREMENT

5.1 General Information

Temperature is a useful measure of the thermal status of a waterbody. Temperature can influence the distribution of species, the rate of chemical, and biochemical reactions, and the metabolic rate of organisms.

5.2 Calibration, Measurement, Data Recording Procedure

Most field meters (and all conductivity and DO meters) are equipped with a thermistor. Therefore, temperature measurement simply involves recording the temperature while taking the conductivity and/or DO readings. The thermistor does not require calibration. Bring a standard glass thermometer into the field to periodically verify the accuracy of the thermistors and as a back-up.

Generally, measurement and data recording are as follows:

a. To start measuring, immerse the thermistor in the ambient water and follow instructions in the operation manual to obtain a measurement.

b. Once the reading reaches equilibrium, record the temperature on the field sheet.

c. Record additional pertinent information in field notes. Accurate field notes must be kept throughout the field program, including any odd measurements (e.g., temperatures less than 0°C) and the rationale for any decisions pertaining to the use of the thermistor.

d. Whenever the thermistor is not in use, immediately store it in a plastic cover with a small amount of water.

5.3 Maintenance

In general, the only maintenance required for the meter is battery replacement and keeping the sensor clean. Conduct all maintenance in accordance with manufacturer's instructions.

6 FROM THE 2018 TO 2020 KOOCANUSA STUDY DESIGN

6.1 General Information

In association with biological sampling, *in situ* measurements of water quality will be completed in April and August from 2018 to 2020. Water temperature, DO, pH, and specific conductance (i.e., temperature-standardized measurement of conductivity) will be measured as vertical profiles at one meter intervals starting just below the water surface. The *in situ* water quality measurements will be taken with a calibrated YSI 556 MDS (multi-parameter Display System) meter equipped with a YSI 6820 Sonde, or similar portable multi-parameter unit. *In situ* water quality will be taken from a central location within each fishing area (Sand Creek, Elk River, and Gold Creek), and at each of the five biological sampling stations located upstream and downstream of the Elk River.